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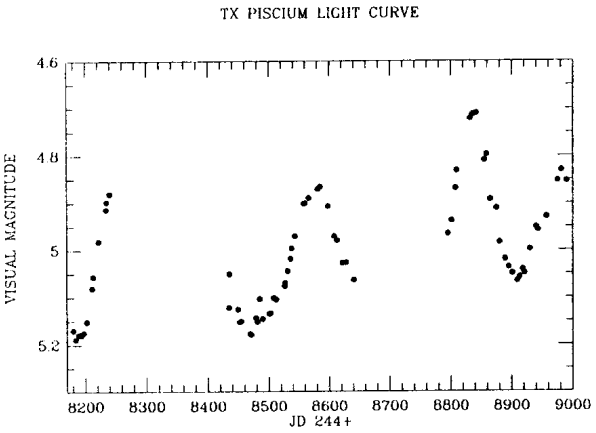
Photoelectric Photometry Of The Carbon Star TX Piscium

TX Piscium (HD 223075, BD +09°2785, SAO 120026, 19 Psc), along with Y CVn, ranks as the brightest carbon star in the sky. It has been one of the most observed stars of its type, and numerous papers have been published on the analyses of its spectrum. The current literature lists various spectral types, most notably C5 II (Hoffleit 1982, Richer 1971) or C6,2 (Johnson et al 1986, Hirshfeld and Sinnot 1985). Johnson et al (1986) describes TX Psc as an irregular Lb giant variable with a visual magnitude of approximately 5.0; this is in agreement with Hoffleit (1982) and Judge and Stencel (1991). Hoffleit (1982), Mendoza and Johnson (1964), and Mitton and McRobert (1989) also all agree on its color index of 2.60.

During the past three years the author has been conducting photoelectric photometry observations of TX Psc as part of the AAVSO Small Amplitude Red Variable (SARV) program. These observations were made to determine its periodicity, if any, and amplitude range. Despite the numerous spectral studies on this star, no published photometric light curve has been found in the existing literature. Additionally, the only data found that pertained to an amplitude range was that published by Mitton and McRobert (1989), who reported a visual amplitude range of 5.3 to 5.8. Hence it is thought that the light curve and supporting data could be the most complete set of data to date that shows indications of semi-well defined amplitude ranges and periodicities.

The observations were made on 71 separate nights from JD 2448180 (15 Oct 90) to JD 2448990 (02 Jan 93). The detector used was a silicon PIN photodiode in a solid-state SSP-3 photoelectric photometer, which was mated to an f/10 8-inch Schmidt-Cassegrain. The observations were made through a SSP-3 Schott visual filter, with the variable star measurements flanked by the comparison star and sky readings. A check star was observed on 68 of the 71 nights. The comparison and check stars used were HD 223719 (V=5.55, B-V=1.53, K4 II) and HD 222368 (V=4.13, B-V=0.51, K7 V), respectively. The mean magnitude difference between these two stars was -1.47 with a standard deviation of 0.02 magnitude. The data were reduced by a computer program written by the author, with all comparison and sky readings being interpolated. Also taken into account in the program were atmospheric extinction, mean transformation to the standard UBV system, and corrections to heliocentric time. The maximum internal standard error for all of the observations, calculated for each individual night, was 0.015 magnitude.



The photometric observations have revealed certain well defined minima and maxima points, which are summarized in Tables I and II, respectively. The resulting light curve is constructed from the data in Table III.

Table I: TX Piscium Minima Data

Times of Minima	Intervals Between Minima (Days)
JD 2448190	290
JD 2448480	215
JD 2448695 (int)	215
JD 2448910	

Table II: TX Piscium Maxima Data

Times of Maxima	Intervals Between Maxima (Days)
JD 2448580	260
JD 2448840	140
JD 2448980	

Note that Table I includes an interpolated minimum at JD 2448695, which is halfway between the observed minima at JD 2448480 and JD 2449910. Also the maxima

Table III: TX Piscium Light Curve Data

JD 244+	Visual Magnitude	JD 244+	Visual Magnitude
8180.547	5.17	8566.527	4.89
8184.536	5.19	8581.552	4.87
8189.514	5.18	8585.505	4.86
8191.563	5.18	8598.464	4.91
8193.550	5.18	8608.463	4.97
8197.539	5.17	8613.464	4.98
8202.495	5.15	8622.469	5.03
8211.506	5.08	8628.480	5.03
8213.533	5.06	8641.471	5.06
8222.473	4.98	8795.851	4.96
8234.461	4.91	8801.817	4.94
8235.471	4.90	8808.820	4.87
8240.475	4.88	8819.836	4.83
8434.860	5.12	8832.752	4.72
8435.817	5.05	8836.749	4.71
8449.816	5.12	8842.723	4.71
8452.810	5.15	8855.696	4.81
8454.813	5.15	8859.706	4.80
8469.804	5.18	8865.664	4.89
8471.756	5.18	8875.642	4.91
8479.750	5.14	8880.624	4.98
8481.806	5.15	8889.665	5.02
8485.724	5.10	8895.590	5.04
8490.733	5.14	8901.595	5.05
8501.683	5.13	8909.564	5.06
8503.690	5.13	8913.558	5.06
8508.667	5.10	8918.529	5.04
8512.641	5.10	8921.525	5.05
8526.595	5.08	8930.521	5.00
8527.611	5.07	8940.484	4.95
8531.616	5.04	8943.484	4.96
8536.586	5.02	8957.483	4.93
8538.590	5.00	8975.528	4.85
8543.565	4.97	8981.478	4.83
8558.583	4.90	8990.482	4.85
8560.516	4.90		

at JD 2448980 could be somewhat suspect, as further observations could not be carried out due to the normal end of the observational season. The average of all time intervals, both minima to minima and maxima to maxima, including the interpolated minimum, is 224 days. This value falls within one of two peak frequencies of period distributions for semi-regular SRb stars of spectral type C and S grouped together (Petit, 1982). Now while all researched references in the literature classify TX Psc as an Lb irregular giant variable star, one might be inclined to view TX Psc as a semi-regular variable of type SRb based on the above "fit" of the average period to that of Petit's period distribution. However, a characteristic of SRb stars is that of superimposed periods, and observations are still lacking to make any definite statements in that area. Hence, TX Psc could be possibly viewed as a semi-regular variable of type SRa, in addition to it being a SRb, instead of the current Lb irregular classification.

Supporting this argument is data regarding distribution of variable carbon star types by the C subclass and carbon content class. Alksne et al (1991) classify the spectrum of TX Psc as C7,2; according to his distribution data, this would denote TX Psc as an Lb irregular giant carbon variable. However, most literature references classify the spectrum of TX Psc as either C6,2 or C5 II, and this spectral type would denote a SR variability type, according to Alksne's distribution data.

Finally, it should be emphasized that, despite there being no one definite period, the observed light curve does show some degree of regularity in terms of periodic brightening and fading. It is not completely irregular, at least for the three observing seasons in which TX Psc was observed. It is possible that the variability of TX Psc is due to the existence of local density enhancements, or clumps, in the envelope around the star (Heske et al, 1989). These clumps could cause erratic outflow of matter in the envelope, producing the semi-regular variability as seen in the light curve. More observations will be needed to either further enhance the argument for TX Psc to be classified as a SR variable instead of a Lb irregular or to refute the above claims.

The amplitude range of TX Psc is also variable, with a total light curve range of 0.46 magnitude. This is in agreement with Mitton and McRobert (1989), who reported a range of 0.5 magnitude. However, while Mitton's value covered a visual magnitude range from 5.3 to 5.8, the visual magnitude observed by the author has been from 4.72 to 5.18. This is somewhat brighter than that reported by Mitton. Furthermore, except for the drop in last apparent maxima to visual magnitude 4.86 at JD 2448980, one can see an overall brightening trend in the light curve. Whether or not this trend continues can only be ascertained by more observations.

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